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SUMMARIES OF REPORTS ON USSR COSMIC-RAY RESEARCH

/Comment: Almost the entire issue of Izvestiya Akademii Nauk SSSR, Seriya Fizicheskaya, Volume XVII, No 1, January - February 1953, was devoted to Soviet cosmic-ray research reports read at the 11 - 13 June 1952 Conference on Cosmic Rays. One exception was D. V. Skobel'tsyn's opening address to the conference [redacted] These research reports are presented here in summarized form.

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According to a note in the source, G. B. Zhdanov, Candidate of Physicomathematical Sciences, was general editor of these reports./

1. "Nature and Properties of Primary Cosmic Radiation," S. N. Vernov, A. M. Kulikov, and A. N. Charakh'yan, Physics Institute imeni Lebedev, Academy of Sciences USSR (pp 13-20)

The authors present data on the proton and meson components of cosmic rays at various latitudes and state that scientists now know also the number of mesons and protons at various altitudes. On the basis of new experimental data presented, the authors can point to the following two fundamental conclusions: (1) The cross section for interaction of $5 \cdot 10^9$ ev protons with nitrogen and lead nuclei is geometrically [illegible], and (2) with an increase in energy of protons from $3 \cdot 10^9$ to $10 \cdot 10^9$ the properties of the protons abruptly change. The authors state that practically only for energies greater than $7 \cdot 10^9$ ev do mu-mesons with energies greater than 10^9 ev occur and that cascade phenomena are observed during the formation of electron-nuclear showers, thus indicating that the nuclear-[illegible] process begins at such an energy.

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The authors acknowledge the participation of Yu. A. Smorodin, T. N. Charakh'yan, K. I. Alekseyev, L. T. Baradzey, V. M. Filatov, A. G. Bednyakov, and P. N. Ageshin.

2. "Interaction of Primary Cosmic Particles of Various Energies With Matter," N. L. Grigorov and V. S. Murzin, Moscow State University imeni Lomonosov (pp 21-38)

This report gives the following fundamental conclusions from the experimental data obtained:

a. Primary particles with energy around 3.10^9 ev on generation of pi-mesons expend in the entire atmosphere only about 35% of their energy, but 60% of the energy is expended in the creation of strongly ionizing particles in nuclear fissions.

b. Primary particles with energy around 20.10^9 ev expend the main part of their energy (80%) on the generation of pi-mesons: 20% of the energy is expended by them on the formation of strongly ionizing particles occurring during nuclear fissions.

c. The process of generation of pi-mesons by primary particles with mean energy 3.10^9 ev has, in general, a one-act character.

d. The process of generation of pi-mesons in the atmosphere by particles of high energy (about 20.10^9 ev) does not occur in one act, but is completed in several acts (not less than three); i.e., a nuclear-cascade process takes place. Here only about 25% of the primary particle's energy is lost in the first act on generation of pi-mesons.

e. During collision of protons of mean energy of the order of 20.10^9 ev with a light nucleus, there occurs in the atmosphere a small number, of the order of unity, of secondary nuclear-active particles that are able to generate pi-mesons.

f. Primary cosmic particles in the atmosphere transmit equal fractions of energy to neutral and charged pi-mesons.

g. The fraction of energy lost by a primary particle on generation of neutral pi-mesons in the first collision with a nucleus is small (of the order of 10-15%) and weakly depends on the energy of primary particles in the energy range 3.10^9-20.10^9 ev.

The authors acknowledge the participation of the following associates of the authors' laboratory: S. I. Srikker, I. D. Rapoport, I. V. Rybin, S. P. Sokolov, F. D. Savin, I. M. Yevreinov, and Yu. K. Pozhel. The authors also thank S. N. Vernov for his discussion of results.

3. "Nuclear Interaction of High-Energy Particles and Wide Atmospheric Showers," G. T. Zatsepin, I. L. Rozental', L. I. Sarycheva, G. B. Khristiansen, and L. Kh. Eydus, Physics Institute imeni Lebedev, Academy of Sciences USSR (pp 30-50)

The authors state that, in spite of the absence of a finished theory of the elementary act, calculation of the nuclear-cascade process occurring in wide showers is of substantial interest. They state that one can consider the development of a shower under various partial assumptions concerning the

elementary act and, by further comparing the results of a theoretical computation with experimental data, one can find also the values of the parameters characterizing the elementary act, which agree with experiments, thus giving the possibility of obtaining data relative to nuclear processes occurring at superhigh energies.

The authors state, however, that even without detailed calculations one can make the following conclusions by utilizing only observed regularities of a general type:

a. The energy spectrum of primary radiation can be approximated by the power function $E^{-\gamma}$ where $\gamma = 1.6\text{-}1.8$, up to energies of about $E_0 = 10^{18}$ ev.

b. Up to energies of about $E = 10^{18}$ ev the cross section of interaction with atomic nuclei is maintained at the order of the geometric cross section; more accurately, 0.7σ geom. This conclusion is due to the fact that a number of phenomena (see, e.g., Cocconi-Tongiorgi, Phys. Rev. 73,923 [1948]; 75,1532 [1949]) connected with wide showers possesses an altitudinal behavior in the form of an exponent with index mu = 1/100 cm^2/gm. Since no phenomenon in cosmic rays can possess an altitudinal behavior characterizable by the mean flight path which would be less than the path for absorption of primary radiation (in complete analogy with the laws for radioactive families), it follows that for primary radiation the index is mu = 1/100 cm^2/gm; taking into account that, for air mu = 1/70 cm^2/gm corresponds to the geometric cross section, we obtain $\sigma = 7/0.7\sigma$ geom.

c. The multiplicity of formation of particles during collision of nucleons increases with energy; for energy of about 10^{13}-10^{14} ev, this quantity (multiplicity) is greater than five. Such a large value testifies to the strong bond of nucleons and the meson field.

d. The fraction of energy transmittable to neutral pi-mesons in the case of high energy of the colliding particles is small and does not exceed 0.2; taking the neutral and charged mesons as similar, one finds that for high energies of the colliding particles a considerable part of the energy is transferred to particles different from pi-mesons. Apparently, at high energy in collisions either nucleon-antinucleon pairs or heavier mesons are generated in addition.

e. In the system of center of inertia of the colliding particles, the angular distribution of generated particles, more precisely the angular distribution of flow of their energy, is essentially anisotropic.

The authors acknowledge the guidance of D. V. Skobel'tsyn; the advice (during the experiments) of V. I. Veksler and N. A. Dobrotin; the help with the experiments from V. V. Miller, Yu. N. Vavilov, I. A. Ivanovskiy, and M. S. Tulyankin; and the valuable judgment of results afforded by S. Z. Belen'kiy.

4. "Multiple Generation of Particles During Collisions of Fast Particles," L. D. Landau, Institute of Physics Problems imeni Vavilov, Academy of Sciences USSR (pp 51-64)

The author derives Fermi's formula for the full number of particles in a system, and the distribution of generated particles with respect to energies and directions.

Author thanks Ye. M. Lifshits, I. Ya. Pomeranchuk, and Ye. L. Feynberg for their considerations of problems discussed, and also L. I. Sarychev for permission to use the figures with the energy spectra of generated particles.

5. "Theory of the Nuclear-Cascade Process in Wide Atmospheric Showers," I. L. Rozental', Physics Institute imeni Lebedev, Academy of Sciences USSR (pp 65-71)

The author concludes that, if one represents the dependence of the number of secondary particles on energy by a power function, then the power index gamma is given by $\gamma = 1/3$, rather close to 1/4; and that taking the nuclear-cascade process into account permits one to reconcile experimental and theoretical data on the composition and spatial distribution of particles in wide atmospheric showers.

The author acknowledges the helpful discussion of Ye. L. Feynberg, N. A. Dobrotin, and G. T. Zatsepin.

6. "Spectrum of Protons in Cosmic Rays and Interaction of High-Energy Protons With Matter," A. T. Dadaya and G. I. Matzon, Physics Institute of Academy of Sciences Armenian SSR (pp 72-79)

The investigation discussed in this report was a continuation of work conducted by A. Alikhanov and A. Alikhanyan at 3,200 meters on Mount Alagez in 1944 - 1947 devoted to an investigation of protons in cosmic rays. The report deals with a recent investigation of the spectral distribution of fast protons, and an attempt to determine the effective cross section of nuclear interaction of high-energy protons with matter.

The authors thank M. I. Dayon, G. A. Martkyan, G. S. Akopyan, L. I. Potapov, and N. V. Shestakovich for helping in the measurements.

7. "Absorption and Interaction With Atomic Nuclei of Particles Generating Electron-Nuclear Showers," S. A. Azimov, N. A. Dobrotin, A. L. Lyubimov, and K. P. Ryzkhova, Physics Institute imeni Lebedev, Academy of Sciences USSR, and Physicotechnical Institute, Academy of Sciences Uzbek SSR (pp 80-87)

The authors arrive at the following fundamental conclusions: (1) Disintegrating particles enter the composition of the component that generates electron-nuclear showers. (2) Absorption of particles with energies of the order of 10^{10} ev which generate electron-nuclear showers occur after approximately three acts of interaction with nuclei, identically in both heavy and also light matter -- i.e.,

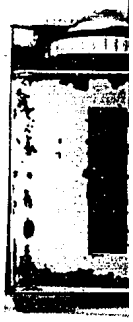
$$(L_a/L_0)_C \sim (L_a/L_0)_{Fe} \sim (L_a/L_0)_{Pt} \sim 3$$

where L_a is mean free path of flight of particles for the case of interaction with matter, and L_0 is the path without interaction. (3) The indicated effect can be explained by proceeding from a representation or concept concerning the presence of an intranuclear cascade process in which all neutral pi-mesons besides other nuclear-active particles must take part.

The authors thank M. N. Shcherbakova and Aleksandr Nevraev, the latter a former student at Moscow State University but now deceased, both of whom assisted in the experimental work.

8. "Decay of Particles That Generate Electron-Nuclear Showers," S. A. Azimov and V. F. Vishnevskiy, Physicotechnical Institute, Academy of Sciences Uzbek SSR (pp 88-91)

The authors state that one of the urgent problems in the study of electron-nuclear showers and of the nuclear-cascade process is the clarification of the nature of the particles that cause secondary cascades. The



authors agree, from their own works and that of others, that both protons and mesons are generated in electron-nuclear showers, and that a significant part of these mesons are pi-mesons. In this connection the authors pose the question whether or not pi-mesons of high energy (10^{10} ev and above) are nuclear-active particles.

The authors describe their own investigations in 1950 (S. A. Azimov, V.F. Vishnevskiy, and N. I. Khil'ko, DAN SSSR, 78, 231 /1951/) and 1951 to clarify this question and to determine the possible existence, in an electron-nuclear shower, of unstable particles that generate new electron-nuclear showers. The authors note, however, that clarification of the problem of decay requires that experiments be conducted free of influence of the transitional effect; this means measuring the absorption in thick layers of a dense substance, where the transitional effect of density is nonexistent.

The authors conclude that the difference between the absorption of nuclear-active particles in water (223 ± 15 gm/cm^2) and in air (123 ± 6 gm/cm^2) testifies to the decay of at least some of the particles that generate electron-nuclear showers, and that the unstable generating particles in dense matter practically do not decay and are absorbed for this reason more slowly that in air. The authors believe that these decaying particles are identical with pi-mesons.

Acknowledgement is made of the participation of N. I. Khil'ko and A. Asadullin in the measurements.

9. "Generation of Protons and pi-Mesons by Neutrons of Cosmic Radiation," M. I. Dayon, Physics Institute imeni Lebedev, Academy of Sciences USSR (pp 92, 93)

The author here summarizes a report published in Doklady Akademii Nauk SSSR, Vol 86, p 1093 (1952). He concludes, from investigations with the magnetic mass-spectrometer (coordinate counters) and studies of impulse spectra of particles, that negative pi-mesons are chiefly generated by neutrons in lead.

10. "Fast Deuterons in Cosmic Rays," A. I. Alikhanyan and G. A. Marikyan, Physics Institute imeni Lebedev, Academy of Sciences USSR and Physics Institute, Academy of Sciences Armenian SSR (p 94)

The authors here summarize a report published in full in Doklady Akademii Nauk SSSR, Vol 87, p 191 (1952).

The authors state in summary that, in 1947, on Mount Alagez, new data was obtained indicating the presence in cosmic rays of fast positive charged particles heavier than the proton; that, in 1950 - 1951, G. A. Marikyan, with the aid of the new magnetic mass-spectrometer, confirmed this conclusion, indicating that in the flow of radiation under a lead block 10 cm thick were observed a noticeable number of particles whose mass as determined according to impulse (momentum) and path of flight exceeds the proton's mass; and that, in 1951, a repetition of the measurements was completed in a 14,000-gauss field, which isolated deuterons with residual flight paths of 3-6 cm/Pb (200-400 mev) representing 10% of the protons with the same paths.

The authors conclude that at least one fourth of all the recorded deuterons are generated in the lead block by fast neutrons, and that the effective cross section of generation of deuterons, with the above indicated energies, by fast neutrons with energies exceeding 500 mev is about two tenths to three tenths of the geometric cross section of a lead nucleus (i.e., $\sigma = (0.2\text{-}0.3)\sigma_0$).

11. "New Elementary Particles in the Composition of Cosmic Rays," G. B. Zhdanov, Physics Institute imeni Lebedev, Academy of Sciences USSR (pp 95-101)

The author discusses two fundamental problems: (1) the study of the composition and properties of the primary component of cosmic rays, and (2) the analysis of the interactions which lead to the occurrence of the principal components of secondary radiation in the atmosphere. The first problem includes study of neutral and charged short-lived particles by means of Wilson cloud chambers and the second, study of decay of heavy charged mesons in photo emulsions, and investigation of mass spectrum of charged particles by the method of magnetic analysis.

The author states that further experiments are particularly needed to clarify the conversions that are undergone by subject particles during their study in matter.

12. "Investigation of the Ionizing Capacity of Relativistic Particles," V. M. Kharitonov, Institute of Physics, Academy of Sciences Armenian SSR (pp 102-113)

The author discusses the results achieved by Western workers (N. Bohr, Bethe, Fermi, etc.).

The author thanks A. I. Alikhanyan for his interest in the present work, L. D. Landau for his valuable advice, A. T. Dadayan for his cooperation in the measurements, and G. Merzon for his participation in the measurements.

13. "A Pecularity of Certain Gaseous Nebulae Which Is Possibly Connected With a Magnetic Field," G. A. Shayn and V. F. Gaze, Crimean Astrophysical Observatory (pp 114-118)

The authors present a general discussion of the results achieved by others. According to the authors, a phenomenon of a magnetic-hydrodynamic character is apparently playing a familiar role in gaseous nebulae, which, lying in a region of electromagnetic excitation, are "frozen" into a gigantic ionized gaseous medium.

The authors state that the purpose of the report was to attract the attention of physicists to the problem, which is large and difficult.

14. "The Energy Distribution of the Particles in Primary Cosmic Radiation," A. A. Logunov and Ya. P. Terletskiy, Scientific Research Institute of Physics, Moscow State University imeni Lomonosov (pp 119-135)

This report presents a detailed study of the motion of cosmic-ray particles in the turbulent flow of an ionized medium. In particular, the authors derive equations for a magnetic field in a conducting medium, and an equation of turbulent flow in a magnetized medium. They also establish a law governing the variation of a magnetic field, and the mechanism for inductive acceleration of charged particles. They derive the principal equation describing the acceleration process, and analyze (1) this equation for the case of a point source without taking the radiation loss into account and (2) the influence of loss due to ionization and radiation. Finally, they solve the principal equation for the case of a point source taking the dependence of the coefficient of diffusion upon energy into account, to obtain a complicated expression $f(r,E)$ for the energy spectrum.

The authors conclude, in summarizing the work, that the theory expounded gives an energy spectrum which agrees well with experiment.

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15. "Variations in Intensity of the Meson Component of Cosmic Rays During the Time of One Cycle of Solar Activity," Ye. S. Glokova, Scientific Research Institute of Terrestrial Magnetism (pp 136-140)

The author states that the clearly evident variation during a solar cycle cannot be due to mere meteorological conditions, since these possess no connection with the solar cycle. He further states that the processes due to solar activity and causing the variation in cosmic-ray intensity is being little studied at present. He conjectures that a certain part of the observed variations connected with solar activity occurs because of processes taking place in the high layers of the atmosphere, which deserves study. The author recommends that measurements of the intensities of the other components of cosmic rays be conducted, which are not subject to atmospheric influences to such an extent as is the meson component, and which could give more definite data on the variations of primary cosmic rays.

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